Project LIE 00008

Working together to deliver multiple benefit messages to growers through a whole systems approach to soil management

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Introduction

Soil acidity has long been recognized as a serious limitation to agricultural production in Western Australia. As a consequence, there has been considerable investment from both the government and private sector in establishing lime trials and demonstrations to show the value of managing soil acidity appropriately.

The Department of Agriculture and Food WA has been a key player in establishing many trials that have been aimed to service both field based research and subsequent extension opportunities. Unlike other agronomic trials, lime trials remain valuable (if relocatable) for many years post their establishment phase.

Obtaining the best extension value from lime trials is always a challenge compared to other field based agronomy. The reasons are complex, but some key issues are:

- The time lag, some trials can take several years to respond and/or 'become visual' can complicate 'extension' opportunities
- Establishment of many lime trials happened when grower interest was far less than it is today, hence there may have been a lack of 'receptiveness' to view and absorb information, and this has now changed
- Tenure of funding and focus on lime is not always aligned optimally, hence valuable lime trials are 'abandoned' before they become important and suitable to promote to growers
- Suboptimal rates of lime initially applied to 'ameliorate' acidity adequately, for example when surface acidity is resolved, but subsoil acidity is still limiting.

Ongoing extension of the importance of lime in farming systems is now more topical for farmers and the diversity of industry people that growers work with. GRDC has supported a new approach to enhance extension opportunities- by 'reusing' some old lime trials.

Since this project commenced, Aglime has successfully located many old lime trials across south west of WA. Many have been soil sampled; others will be sampled during the next sampling season.

Forward

With the widespread recognition of extent and severity of soil acidity as a limitation to agriculture in WA, there have been many projects involved in the establishment and subsequent monitoring of the trials and demonstrations of using lime. One of the key extension tools used in the mid 1990's was the establishment of large scale (farmer equipment) demonstration sites to provide a valuable resource for research and serve as a reference point to assess the benefits of liming across WA. Many of these early trials are being relocated, soil sampled, and used for extension purposes now - which is testament to the foresight of those involved in establishing them.

Many people contributed to the establishment and conduct of lime field trials and demonstrations, particularly the Western Australian Soil Acidity Research and Demonstration team:

- Chris Gazey
- Amanda Miller
- Dave Gartner
- Sandy Pate
- Geoff Anderson

Other DAFWA staff also assisted with the process:

- Mike Bolland
- Nancye Gannaway
- Vicki Bolt
- Dan Hester
- Jason Brady
- Andrea Hills
- Jasmine Cheetham
- Colin Holt
- Adrian Cox
- Meg Howe
- Tony Clark
- Kylie Jensen
- Jenny Crisp
- Brendan McAuliffe
- Don Cummings
- Darren Morris
- Eliza Dowling
- Graham Mussell
- Amanda Just
- Tim Wiley

For early data relating to some the trials reported in this document, the reader is directed to:

Penny, S. and Gazey, G (2002) Western Australia Soil Acidity. Demonstration Site Results 1996-2001. Department of Agriculture **Misc Publication 24/2001. ISSN 1326-4168**

Acknowledgements

The 'Time to Lime' project was a major coordinated research and extension initiative during which time, many of the trials reported upon were initiated, and many organisations contributed:

- Grains Research and Development Corporation
- Department of Agriculture, Government of Western Australia
- National Landcare Program
- Land and Water Resources Research and Development Corporation
- National Heritage Trust
- CSIRO Australia
- Centre for Legumes in Mediterranean Agriculture
- The University of Western Australia
- Australia Fertiliser Services Association

I acknowledge GRDC project LIE00008, "Working together to deliver multiple benefit messages to growers through a whole systems approach to soil management" for financial support, and the staff at Liebe Group Inc for their management support.

Special thanks to Chris Gazey (Senior Research Officer, DAFWA Northam) and David Gartner for the detailed records kept from the trial establishment phase, and their subsequent assistance in locating this series of field trials.

Methodology

Aglime of Australia has been engaged as the sub-contractor involved in relocating, and resampling these old lime trials. The data reported, and the individual comments made on each trial are delivered in good faith, but should not necessarily be used in isolation in delivering widespread extension messages.

This document contains the five trial reports, and represents the summary of data collected during the project and has been reported against the initial treatments as described by DAFWA (the trial initiator). In some cases, there have been subsequent treatments (ie additional lime) applied to the original trial design. DAFWA is still looking at the full array of additional treatments (for example, combinations of additional lime and tillage options). All pH measurements reported in this document have been measured in the standard 1:5 soil: 0.01M $CaCl_2$.

For simplicity only the initial lime treatments and if any subsequent lime has been applied are reported at this juncture.

It is extremely important to clarify that none of the trials reported on, have been under 'scientific management' for many years. Typically the trials reported upon were established, and under a regime of careful management and monitoring typically associated with DAFWA field based research for various times frames (typically for between 3 and 8 years). Since that time, they have all simply remained 'as a zone treated as the rest of the paddock 'within the normal farm management regime imposed by the cooperating farmer. In some cases, farms have been sold. Despite concerted attempts, complete understanding of any additional inputs imposed on the trials sites is not known.

Disclaimer

Aglime of Australia, neither DAFWA nor the cooperating farmer has full documentation of all inputs on these sites over that time frame since their establishment. On this basis therefore utmost care must be taken in drawing any isolated conclusions from the data. For instance additional lime, or fertilizer or herbicides could have been dumped on sections of the trial, and this could have influenced soil condition as reported in this document.

Aglime of Australia strongly emphasizes this is preliminary data, and in effect represents 'a photograph in time' in relation to the longevity of time elapsed since the establishment of these field experiments. This is very important, considering the large time lapse involved since trials were established and managed as per the requirements of the researcher involved. In some experiments, known additional treatments have been imposed, albeit typically 2 to 10 years post the initial establishment. Drawing conclusions from either the initial or subsequent treatment applied, and direct attribution of any differences today must be carefully considered.

Aglime of Australia strongly advocates contacting Chris Gazey (Senior Research Officer at DAFWA)
Email: chris.gazey@agric.wa.gov.au Mobile 0429 107 976 prior to making any statements about any of the preliminary data reported in this document.

01ME90 – Kelvin Kent Bodallin

Key Messages

- There was no significant pH changes within the first year of the demonstration however there was a trend for an increase in subsoil pH of 0.2-0.3 pH units following deep banding of lime.
- Predicted some of the lime deep banded in 2001 would remain undissolved and further pH increases should take place subsequently.
- Despite not significantly changing soil pH, there were first year yield responses in wheat following ripping, and the injection of lime.
- From a perspective to have lime react, it would seem imperative to have a deep tillage operation every few years. Once a certain portion of lime has reacted, the residual lime then sits in a highly alkaline (caused by the dissolution of some of the lime applied) zone, within a highly acidic soil. The chance of the excess lime present deep in the soil profile coming into contact with acid soil, to subsequently react and change more of the overall soil pH appears to be reliant upon some degree of mechanical intervention.

Aim
The focus was on being able to rip and inject lime to depth, to attempt to alleviate the acidity and aluminium toxicity that resulted from the low pH

Background
This trial, 01ME90 is on a deep acid sandplain had an average topsoil pH of 4.4 an average subsurface (10-20 cm) pH of 4.3, and 20-30 cm depth of 4.3 when established. To address subsoil acidity and aluminium toxicity problems particularly below 15 cm, limesand was deep banded using a modified deep ripper capable of delivering up to 1 t/ha of lime to depth

Trial Details

Property:	Kelvin Kent, Bodallin
Plot size & replication:	12m wide, 100 m long, area per plot 0.12 ha. Initial 5 treatments by 4 replicates
Soil type:	Yellow sandplain (wodgil)
Soil pH ($CaCl_2$):	Initially 4.4 (0-10cm) over 4.3 (10-20cm)

Initial treatments 2000
Treatment 1 Ripping at 10-15 cm
Treatment 2 Ripping at 10-15 cm and again at 15-20 cm
Treatment 3 Ripping at 10-15 cm and blowing lime in at depth at 1 t/ha
Treatment 4 Ripping at 10-15 cm and again at 15-20 cm and blowing lime in at depth at 1 t/ha
Treatment 5 Control

Subsequent treatments 2004
In 2004, each initial plot (dimensions 12m wide by 100m long) was split in two. One half (6m wide) was top-dressed with 2t/ha, the other half did not have any additional lime applied. Hence, there were subsequently 10 treatments by 4 replicates. For this report this season, we are only reporting on 6 treatments.

Subsequent lime application across the trial
In March 2016, part of the trial was top-dressed with a further 2t/ha, with deep cultivation (circa 25cm) with offset discs. Subsequent measurements will be made this growing season.

Selection of initial soil parameters at the beginning of this trial

2001 soil pH

Depth	Nil	Rip 1	Rip 1 plus lime	Rip 2	Rip 2 plus lime	LSD
0-10cm	4.8	4.8	4.9	4.6	5.0	ns 0.2
10-20cm	4.3	4.4	4.5	4.2	4.5	ns 0.2
20-30cm	4.4	4.3	4.4	4.3	4.4	ns 0.3
30-40cm	4.4	4.3	4.3	4.3	4.3	ns 0.3

2001 Soil Aluminium (mg/kg)

Depth	Nil	Rip 1	Rip 1 plus lime	Rip 2	Rip 2 plus lime	LSD
0-10cm	0.5	0.5	0.5	1.9	0.5	1.0
10-20cm	3.9	5.0	1.5	8.9	2.6	5.8
20-30cm	3.9	7.7	10.5	12.6	3.6	8.2
30-40cm	5.4	9.2	13.0	14.9	5.1	11.2

Interestingly, the initial prediction by Gazey (trial initiator) that some of the injected lime would remain undissolved in 2001 has been verified, albeit 15 years post his forecast (Figure 3). Despite a fine grained lime source being used to establish this trial site, this photograph provides clear evidence of the need to use mechanical incorporation when liming these soils. Despite fine grained material being 'blown down' to a depth of 30cm, into extremely acidic subsoil, not all the lime has reacted, even after 15 years.

Figure 3. Unreacted lime, 15 years post application. This lime was collected from the bottom of the 30 cm deep 'purple zone' which is highlighted by pH indicator (Figure 4)

Whilst there are adverse impacts from tillage, from a perspective to have lime react, it would seem imperative to have a deep tillage operation every few years. Once a certain portion of lime has reacted (as evidenced by Figure 4), the residual lime then sits in a highly alkaline (caused by the dissolution of some of the lime applied) zone, within a highly acidic soil. The chance of the excess lime present deep in the soil profile coming into contact with acid soil, to subsequently react and change more of the overall soil pH appears to be reliant upon some degree of mechanical intervention.

To further investigate the impact of additional lime, and tillage in combination in March 2016, part of the trial was top-dressed with a further 2t/ha, and a deep as possible cultivation with offset discs. Subsequent measurements will be made this growing season.

Figure 4. Deep ripped lime applied in 2000, a slot of 30 cm deep, the ‘purple zone’ is highlighted by pH indicator. The unreacted lime in Figure 3 was from the bottom of this band

2016 soil pH

Initial treatment 2001	Subsequent treatment 2004	Soil pH 0-10 cm	Soil pH 10-20 cm	Soil pH 20-30 cm
2001 Control (no lime	2004, nil	4.2	3.9	4.2
2001 Control (no lime)	2004, 2 t/ha lime	4.8	4.2	4.3
2001 Rip twice (no lime)	2004, nil	4.2	4.0	4.0
2001 Rip twice (no lime	2004, 2 t/ha lime	4.9	4.2	4.2
2001 Rip twice 2t Lime	2004, nil	4.2	4.3	4.8
2001 Rip twice 2t lime	2004, 2 t/ha lime	5.1	4.7	5.0
LSD		0.5	0.5	0.8
		0.3	0.3	0.4
		0.3	0.3	0.4

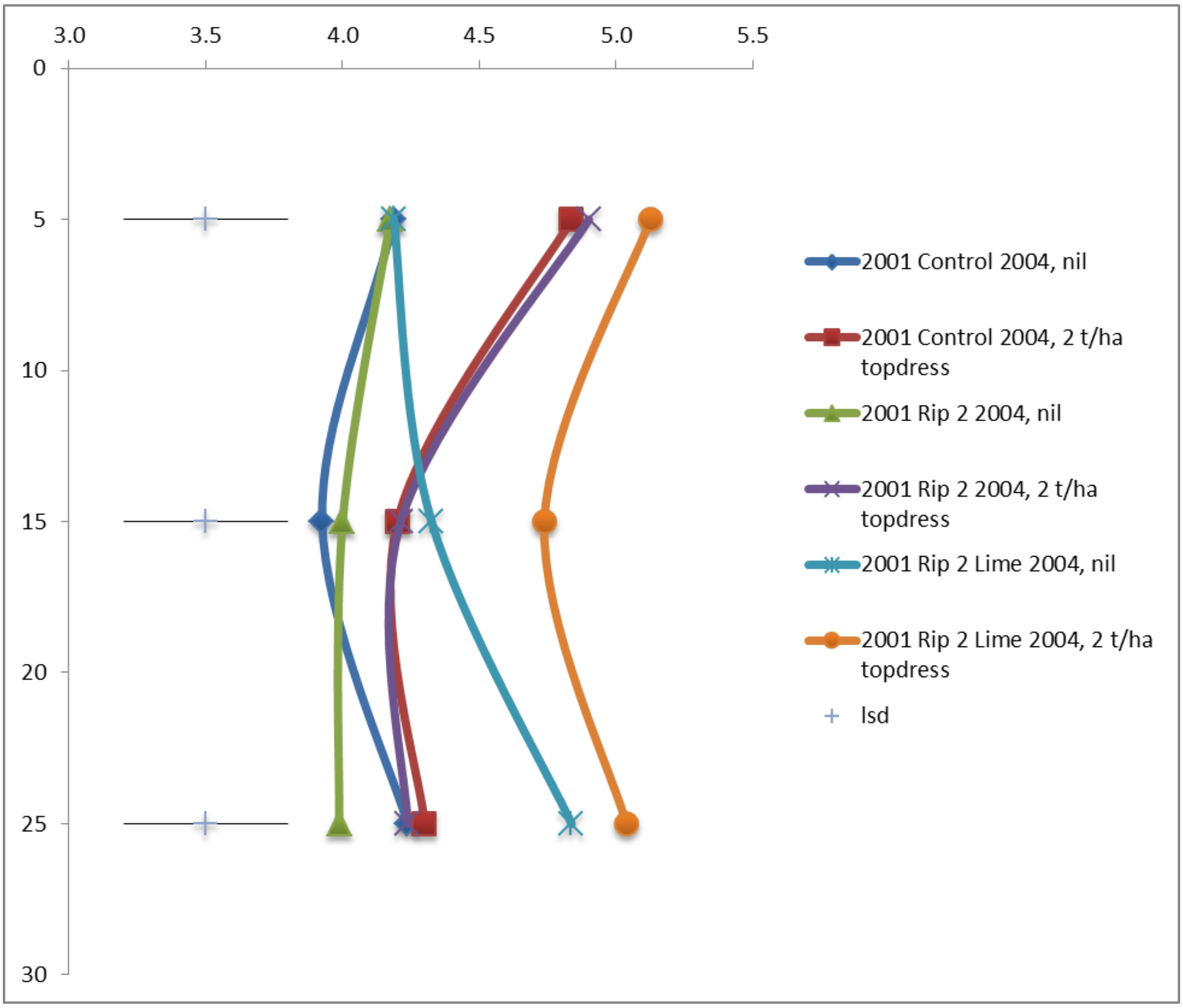
Comments
This trial was established on an extremely acidic wodgil soil. It would now seem the rates of lime incorporated by injection were perhaps insufficient to eliminate all the acidity present, but were the best that could be achieved with the equipment available at that time.

None of the profiles have a soil pH at or above the DAFWA suggested targets (5.5 in the surface soil, and 4.8 at depth)(Figure 5). This is not unexpected given the initial pH and the amount of lime applied. What is extremely encouraging is the distinct separation of pH profiles, which are logical based upon the rates and timing of lime application. The best pH profile has been achieved with the twice ripped, with lime injection, followed by an additional 2t/ha top-dressed in 2004. Compared to the nil limed, there is circa 1 pH unit difference all the way to 30 cm.

These extremely acidic sandplain soils in the Eastern wheatbelt are relatively common in certain zones. The economics of applying adequate good quality lime sourced from the coast a large distance away, and effectively mixing it in, has always presented a significant challenges to adoption in the low rainfall zone.

Results are encouraging, albeit with insufficient lime to repair the whole soil profile to the target soil pH. Further soil testing after harvest 2016 is planned, to evaluate the impact of an additional 2t/ha of lime, and a more aggressive tillage (offset discs as deep as possible) which was undertaken in March 2016.

Figure 5. 2016 soil pH profiles following lime and tillage treatments applied in 2001 and 2004.



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APPENDIX

GRDC has funded this cooperative program involving Liebe, MIG, WMG and South DIRT group and Aglime of Australia to have soil acidity better managed across the state. Given the project title “Working together to deliver multiple benefit messages to growers through a whole systems approach to soil management”, raising awareness about the importance of understanding soil acidity, and it limitations to profitable agriculture is a critical focus of all project partners.

To achieve this regime, in addition to sampling the ‘old long term lime trials’, Aglime has been instrumental in trying to encourage growers to recognize the importance of actually making soil pH measurements in their own trial and demonstration programs.

In addition to the soil sampling milestone requirements, Aglime has focused on ways to enhance growers, and the various staff from many organizations they are working with to gain a better understanding of the variation in soil type, and the importance of adequate pH measurement, before and post the application of various lime and tillage treatments.

A key focus of this approach has been to establish dialogue, and create ‘small nodes’ of activity related to trialing and demonstrating using lime to treat acidity across the WA wheatbelt. The rationale is to help growers understand the issues, and ultimately to help growers to help themselves.

One approach taken to achieve this objective has been to offer comprehensive soil sampling to growers involved in establishing and monitoring their own field trials. During the first two years of this project, Aglime has sampled for various collaborators (data not shown in this report). All data has been returned to the various project staff, who will report direct to the organisations they receive funding from, and cooperate with in their various programs. Aglime does have copies of all this raw data and the geo locations of the collection sites, and it can be made available to GRDC upon request.

Some of the relevant examples across the WA wheatbelt include:

Brian Cusack- Narembeen
Travis Hollins- Nungarin
Dennis Martin- Badgingarra
Will Browne- Warradargee
Peter Negus- Dandaragan
Murray Preston- Geraldton
Tony Sasche- Bencubbin
Ben Hobley- Nyabing
Tony Murfit- South Burracoppin

We have tried to address this issue, albeit with a small number of growers in the state, and the ‘end result’ of considerable field sampling and literally hundreds of soil pH measurements from a single field trial is often only a simple graph, with small numbers of pH profiles reflecting various treatments over time.

Most growers and consultants understand the pH scale (logarithmic), and the fact a soil with a pH of 4.5 has ten times the acid concentration of a soil at pH 5.5. However, very few understand the impact of initial soil pH on the rate of lime reaction. Whilst the acid concentration is 10 fold for 1 pH unit, the rate of lime dissolution in the field is more typically 100 fold for a 1 pH unit change (i.e lime dissolves 100 times faster at pH 4.5 than it does at pH 5.5).

The implications of this chemical fact, in broadacre field trials looking at low (typically 1 or 2t/ha of lime) rates of lime is grossly underestimated, and inadequate interpretation of the effectiveness of lime in treating soil acidity is usual thereafter. If farmer trials are inadequately designed and replicated (and many are), and the starting pH of the plots nominally allocated as the control or nil lime plots simply by chance happens to be at pH 4.8, and the starting pH of the plots receiving 2t/ha by chance start at pH 4.2, then a typical conclusion 12 months post lime trial establishment is that ‘lime didn’t work’ in changing the soil pH.

If adequate numbers of soil cores and replications of the various treatments are made at the start of a lime trial, and again post treatment, then erroneous conclusions are less likely. However, like many issues, the time involved to collect enough soil samples, and the lack of willingness to part with the money required to make the appropriate number of pH measurements (CSBP lab in Perth charges $14 per sample for a pH measurement) generally means a compromise is made. This needs to be understood.

Another issue with farmer established lime trials that does impact on results obtained is the fact growers are using a variety of lime sources, and often of unknown quality. The concept of a ‘bargain’ source of lime which maybe advertised at a lower price per tonne would seem to appeal to many, despite the fact its neutralising value may be vastly inferior to another source of lime available at a marginally higher listed price.

Added to the complication of neutralising value is the issue of particle size. In the drying climate WA wheatbelt farmers operate in, the importance of particle size of lime sources is grossly underestimated by far too many.

It is an unequivocal fact, finer particles react quickest. The do not react more, simply faster. If soil acidity is limiting productivity (and again the facts are clear this is the case), getting lime to react as fast as possible is imperative.

Even in the case of some of the work reported in this document when high NV lime, of a very fine particle size has been used, there is still clearly unreacted lime at depth 15 years post treatment. Whilst there can be no argument, tillage of certain soil types can have negative (as well as positive) outcomes, the evidence presented in the photographs is not uncommon across many WA lime trials. Inadequate mixing of lime and acid soils is common, and restricting access to the economic benefits correct amelioration offers.

Whilst lime use has clearly increased dramatically over the past ten years, the vast majority of lime applied across rural WA has simply been top-dressed on the surface. In many circumstances, surface acidity is not the culprit in limiting yields. If surface soils have been limed, and the current pH of this layer is improved (say from 4.5 up to 5.4), then any subsequent lime applied to the surface (without mechanical mixing) will have little impact on the soil pH in the deeper layers, which are still acid, and are still limiting access to water and nutrients at depth, and ultimately yield.

Farmers now better understand the need to use lime in managing acidity, however incorporation technology/process, the array of machinery options and the impact of the diversity of soil types across the state represent some considerable challenges that needs far better resourcing.